Shrapnel and high-explosive fragmentation warheads

High-explosive fragmentation and high-explosive warheads of missiles form one of the most extensive and developed classes of ammunition designed to destroy almost all types of targets, with the exception of underground, underwater and heavily armored ones. In the modern interpretation, fragmentation warheads (**FWPs**) mean ammunition that strikes a target with a high-speed flow of a large number of similar inert submunitions (**PE**) thrown by an explosion of a charge of high explosive elements (**GGE**). Thus, the term "fragmentation" in the broad sense of the word is outdated, and the concept "fragment" should be attributed only to natural fragmentation fragments.

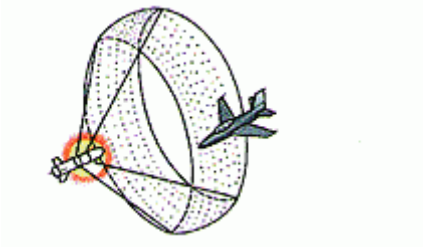
High-explosive fragmentation warheads (**OFBCH**) differ from fragmentation **warheads by** their ability to penetrate into the ground or behind another obstacle before detonation, both within the rocket and outside it. In the strict sense of the word, the term OFBCH is applicable to ground-based missiles, anti-ship missiles, etc. Sometimes, wishing to emphasize the fact that on small misses it is possible to hit an anti-aircraft target by an air shock wave and detonation products, the term "high-explosive fragmentation" is also used for warheads of anti-aircraft guided missiles with non-contact blasting, which is methodologically incorrect. In this case, it would be more correct to use the term "fragmentation-compression warhead", which corresponds to the English term " *High Explosive Blast Fragmentation Warhead* ".

Classification By Target Type:

- **multipurpose** or universal (for example, OFBCH natural crushing of multiple launch rocket systems)
- **specialized** , designed to engage targets of a certain class.
    - anti-personnel warheads designed to destroy open and weakly protected manpower (conditional range of PE masses m = 0.1-1 g),
    - anti-vehicle warheads designed to destroy ground and air unarmored vehicles (m = 1 - 10g)
    - anti-armored warheads designed to defeat lightly armored targets with a steel equivalent of up to 20 mm and other durable low-vulnerability targets, such as tactical missiles (m = 10 - 100 g).

By the configuration of the fragmentation field:

- **OBCH with circular fields** ;



This type of warhead is the most common, its main advantages are the highest utilization rate of explosives, the ability to locate the warhead anywhere on the missile and hitting the target on an arbitrary side of the miss. The relative masses of circular warheads (the ratio of the warhead mass to the launch mass of the rocket) usually ranges from 0.075 to 0.1.

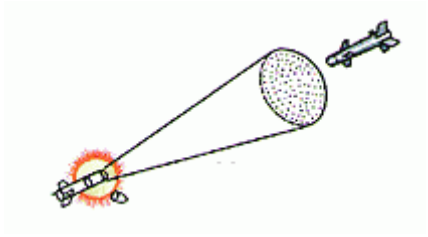
Narrow and wide fields are distinguished by the magnitude of the meridional angle of expansion for the OPH of this type. The spreading angle is mainly determined by the shell shape and the initiation scheme. Small angles of expansion (fragmentation fields of the "cutting disk" type) are implemented using a shell with a concave generatrix, two-point initiation at the ends of the charge, multipoint synchronous initiation along the charge axis, which creates a diverging detonation wave close to cylindrical. Large spreading angles are usually achieved by using a barrel-shaped or, in the extreme case, spherical shape.

The main disadvantage of circular SPGs, which have more or less wide fields required for reliable target coverage, is the low density of the fragmentation field (low density of the kinetic energy of the fragments per unit solid field angle). Effective destruction of modern air targets, primarily such small targets as ballistic and cruise missiles, requires an angular energy content of the

fragmentation flow of 10-20 MJ / steradians, which, in principle, cannot be achieved in the design

of circular warheads. Therefore, the trend of further development, apparently, will consist in the transition to directional fragmentation fields, which make it possible to achieve a high concentration of energy in the fragmentation flow.

- **OBCH with axial fields** ;

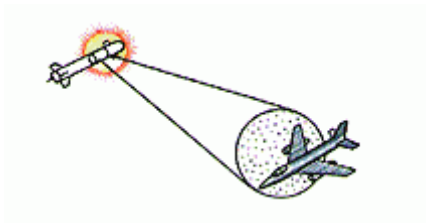


The main advantage of axial warheads is the direct summation of the velocities of the missile and the missile missiles, and for ground-based missiles, the greater depth of destruction when approaching the surface at a low angle. In the latter case, the axial field makes it possible to obtain an optimal match between the dispersion density and the coordinate law of damage.

A significant disadvantage of the axial layout is the need to locate the main unit in the head of the projectile or to drop it before detonating the compartment in front of the unit, as well as the need for high targeting accuracy.

OCH with axial fields are ineffective against maneuvering aircraft and high-speed targets.

- **OBCH with radially directed fields** ;



The main ways to implement a radially directed flow (targeting in a plane normal to the trajectory of the projectile) are:

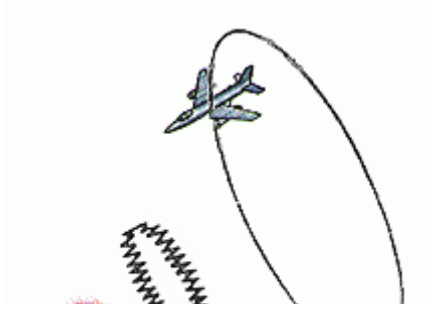
- projectile roll control;
- rotation before detonating a non-axisymmetric OCH around the longitudinal axis;
- multi-point sliding initiation;
- explosive deformation of OCH before detonation;
- disclosure of the OBCH to the plane.

The first two options require a more complex design, since before detonating the warhead, it is necessary to ensure its rotation to align the direction of flight of the fragments with the target.

The highest speed in terms of targeting time is possessed by multipoint sliding initiation (i.e., the creation of a shock wave of the required direction in the explosive charge), but the achieved redistribution of the flow energy is small in this case. A warhead with explosive deformation has a sufficiently high speed (tn = 0.001 - 0.003 s). In this case, the fragmentation shell is made of plastic steel or rubber with a GGE built into it. On the generatrix of the shell with a charge of plastic explosive, detonating elongated charges (DUS) with dampers are located. After receiving information about the side of the miss, the DUZ located on the side of the target explodes, deforming the warhead, and then it is detonated by a detonator with the formation of a directed stream of fragments.

When the OCH is opened into a strip, the four quadrants that make up the warhead are opened at the moment of detonation towards the target and are initiated. It takes several milliseconds to operate such a warhead, which significantly limits its use.

- **rod warheads** ;



Designed for action on aircraft panels. The main element of the rod warhead is a set of rods of square or circular cross-section, laid on the surface of the charge, usually at a slight angle to its generatrix. The rods can be connected (welded) alternately with the upper or lower ends, or not be connected to each other. When detonated, they fly apart, forming a continuous ring when the rods are connected, and an intermittent one with overlapping when not connected.

The advantage of rod PEs over conventional compact GGEs consists in making a continuous cut of the skin and a force set, leading to the destruction of the airframe structure, i.e. destruction of an air target according to the class "instant destruction of a target in the air".

The disadvantages are: a low rate of expansion of the ring (its increase can lead to premature destruction of the ring), a small radius of damage and insufficient cutting ability of the rods when acting against some strong targets.

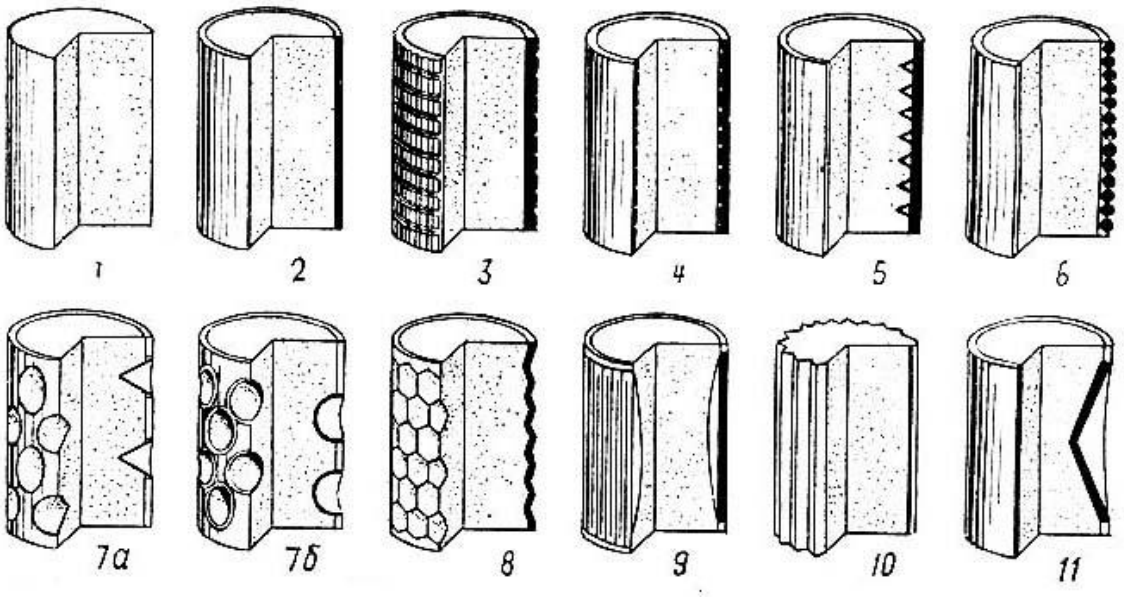
In the designs of **fragmentation-rod warheads, a** layer of compact GGE is laid on top of the set of rods.

In foreign literature, rod warheads are designated as *"High Explosive Continuos Rod"* .

Target hitting mechanism.

Each kilogram of explosive (explosive) contained in the warhead charge produces about 1m3 of gas, which creates a local pressure of up to 100 t / cm2. This gas, heated to a temperature of 3000-5000 ° K, rapidly expands and, compressing the surrounding air, forms a shock wave in it. The defeat of the target by a shock wave and detonation products of explosives is called high-explosive (compression).

If the explosive charge is enclosed in a solid (usually metal) shell, then the gases obtained as a result of detonation break it, which causes the scattering of fragments (PE) at high speeds depending on the ratio of the charge mass to the total mass of the warhead (this ratio is called the filling factor Warhead). After rupture of the shell, the fragments for some time perceive the accelerating effect of expanding gases - explosion products. With the help of fragments, the damaging energy spreads over distances exceeding the radius of the high-explosive action of the warhead, but only in the direction of the flight of the fragments (the field of high-explosive damage is continuous).



Possible designs of the OBCH

- 1-high-explosive;
- 2-explosive charge in a metal shell;
- 3-outer shell notch;
- 4-internal notch;
- 5-explosive charge with grooves;
- 6-ready PE;
- 7-multi-cumulative warhead (with conical and spherical recesses);
- 8-cell charge;
- 9-bar;
- 10-cutting;
- 11-way action.

Without taking special measures to organize the crushing of the shell, the resulting PEs differ significantly from each other in mass and size, and a large proportion of the explosion energy falls on small fragments that quickly decelerate in the air, which do not lead to a noticeable damaging effect due to the low energy delivered to the target. For the organization of crushing, various techniques are used related to the machining of the warhead body, the formation of special recesses on the surface of the warhead, the use of ready-made PE, and others.

When conical or spherical recesses are used, the so-called cumulation effect occurs. with the help of which it is possible to obtain a certain amount of heavy fragments, having an expansion velocity of up to 4-5 km / s. Warheads of this type are sometimes called *multi-cumulative* , and the resulting fragments are called *shock nuclei* .

The effect of the impact of PE on the target is usually estimated using statistical models, which describe the configuration of the target and the location of its main vulnerable compartments, the parameters of the warhead (the size and number of the PE, the velocity and angles of their expansion, etc.), the conditions of the missile meeting with the target (speed, approach angles, position of the warhead detonation point).

In the process of modeling, the following characteristics are usually identified, the analysis of which makes it possible to calculate the degree of target destruction:

- penetration depth (considered the main indicator);
- penetration depth together with the configuration of the hole (determines the effectiveness of impact on a number of target elements - cables, control circuits, hydraulic systems, etc.);
- the amount of movement of the PE (determines the deformation of the target elements);
- kinetic energy, which determines the size of damage to large targets;
- the effect of structural destruction as the ratio of the PE energy and the target value;
- the rate of absorption of energy by the PE target.

It is possible to increase the probability of hitting a target by increasing the energy of the PE, which is ensured by the use of large warheads with heavier and faster PE. Another way to increase the effectiveness of a fragmentation warhead is to ensure a large number of hits of PE on the target. In this case, the effect of the accumulation of damage is manifested, as a result of which the total result of the impact on the target turns out to be higher than the simple sum of individual effects. If several PEs hit the target in a small area and with a short time interval, an additional effect of increasing damage may occur, caused by the following reasons:

- the imposition of a series of shock waves caused in the structural elements of the target by each hitting PE;
- explosive reactions of the compound with oxygen of a part of the target material and PE, evaporated during the penetration of PE (this phenomenon is especially noticeable when it occurs in the internal cavities of the target and when a series of PE causes quasi-static overpressure);
- water hammer that occurs when PE enters a fuel tank or other container with liquid.

Experiments carried out at the Messerschmitt - Belkov - Blom association have shown that when PE enters a tank with a liquid, its penetration is insignificant and practically does not depend on speed. A series of shots of 3.5-g PE into a container with water was carried out at speeds of 600-1800 m / s. It turned out that the maximum penetration was achieved at speeds of 800-1000 m / s. At lower speeds, the PE flattened, and at higher speeds (over 1000 m / s), it assumed a mushroom shape and began to erode. An increase in the PE area and a decrease in its mass led to a decrease in the penetration depth. However, with high-speed fragments, the container received more significant damage due to a more powerful shock wave of the liquid. The time intervals between the fragments required for the manifestation of the effect of enhancement of destruction depend on the speed of propagation of the shock wave in the medium,

Sources:

1. A. Belov "Warheads of missiles to destroy air targets", Foreign Military Review N2, 1987.
2. V. Odintsov "Fragment warheads of missiles: development prospects", Military parade, July-August, 1998.

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